

Amendments to the Claims:

This listing of claims replaces all prior versions and listings of claims in the application:

Listing of Claims:

1. (Currently amended) A method of acousto-optical imaging of an object to be imaged comprising the steps consisting in:

- (a) generating an incident optical wave, of frequency  $f_I$ , and a reference optical wave, of frequency  $f_R$ , this reference wave being coherent with the incident wave, and exhibiting therewith a known phase difference  $\phi_i(t)$ ,
- (b) vibrating in a first object direction and at an acoustic frequency  $f_A$ , a zone of the object to be imaged with the aid of a vibration generating device, and generating an acoustic wave, focused at a focal point situated in the object to be imaged,
- (c) applying said incident wave to the object to be imaged, and thus generating a scattered signal wave,
- (d) applying at least a part of the scattered signal wave to a detection device,
- (e) applying the reference wave to the detection device without making it pass through the object to be imaged, thereby generating at the point  $r$  of the detection device an interferogram  $I(r, t)$  varying over time  $t$ ,
- (f) extracting a digital information item from the interferogram  $I(r, t)$ , and
- (g) obtaining the coordinates of a the focal point of measurement of the object to be imaged, to which the digital information item relates, and

(e) repeating steps (a) to (g) for various focal points of the acoustic wave in the object to be imaged, these various focal points being aligned along the first object direction.

2. (Original) The method of acousto-optical imaging as claimed in claim 1, in which in the course of step (f), an acoustic component of the part of the scattered signal wave applied to

the detection device is detected, this acoustic component being at a frequency corresponding to the sum of the frequency  $f_l$  of the incident wave and of a harmonic of the acoustic frequency  $f_A$ .

3. (Original) The method of acousto-optical imaging as claimed in claim 2, in which, in the course of step (a), said reference wave is generated at a frequency  $f_R$  equal or substantially equal to the sum of the frequency  $f_l$  of the incident wave and of said harmonic of the acoustic frequency  $f_A$ .

4. (Cancelled)

5. (Cancelled)

6. (Currently amended) The method of acousto-optical imaging as claimed in claim 1, A method of acousto-optical imaging of an object to be imaged comprising the steps:

(a) generating an incident optical wave, of frequency  $f_l$ , and a reference optical wave, of frequency  $f_R$ , this reference wave being coherent with the incident wave, and exhibiting therewith a known phase difference  $\phi_i(t)$ ,

(b) vibrating in a first object direction and at an acoustic frequency  $f_A$ , a zone of the object to be imaged with the aid of a vibration generating device,

(c) applying said incident wave to the object to be imaged, and thus generating a scattered signal wave,

(d) applying at least a part of the scattered signal wave to a detection device,

(e) applying the reference wave to the detection device without making it pass through the object to be imaged, thereby generating at the point  $r$  of the detection device an interferogram  $I(r, t)$  varying over time  $t$ ,

(f) extracting a digital information item from the interferogram  $I(r, t)$ , and

(g) obtaining the coordinates of a point of measurement of the object to be imaged, to which the digital information item relates,

in which, in the course of a first iteration, steps (a) to (f) are performed for a first frequency  $f_A$  of the acoustic wave and a first frequency  $f_R$  of the reference wave, in the course of

at least a second iteration, steps (a) to (f) are repeated for a second frequency  $f_A$  of the acoustic wave and a second frequency  $f_R$  of the reference wave, these second frequencies being coded respectively with the first frequencies, the method furthermore comprising a step in the course of which:

(f') at least one digital information item is obtained by decoding said digital information items obtained in the course of steps (f) of each iteration as a function of the frequencies used, and

in which, in the course of step (g), the coordinates of at least one point of measurement of the object to be imaged to which the digital information item obtained in the course of step (f') relates are obtained, by decoding the said digital information items obtained in the course of steps (f) of each iteration as a function of the frequencies used.

7. (Original) The method as claimed in claim 6, in which the sequence of following operations is performed:

- a scan is performed of the frequency of the acoustic wave, which is focused on an interval of points with coordinates extending around the point with coordinates along the first object direction,
- a scan is performed jointly of the frequency  $f_R$  of the reference wave in such a way as to keep  $f_R$  substantially equal or equal to  $f_I \pm H.f_A$ ,  $H$  being a nonzero integer,
- an interferogram  $I(f_A, V, W, r)$  associated with the set of points of the extended interval is recorded for each pixel  $r$  and for each frequency  $f_A$ ;
- a 1D ~~frequency~~ → time frequency-time Fourier transformation is performed, for each pixel  $r$ , according to the frequency  $f_A$  of the interferogram  $I(f_A, V, W, r)$ , and
- at least one interferogram  $I(r)$  associated at least with a measurement point with coordinates is obtained by replacing the time obtained after the Fourier transform with the magnitude  $U'$  along the first object direction ( $x_o$ ) with the aid of the speed of propagation of the acoustic wave in the object to be imaged.

8. (Original) The method of acousto-optical imaging as claimed in claim 1, in which at least steps (a) to (g) are repeated after having imposed a displacement of the vibration

generating device relative to the object to be imaged along a direction not parallel to the first object direction ( $x_0$ ) of the object to be imaged.

9. (Currently amended) The method of acousto-optical imaging as claimed in claim 4 A method of acousto-optical imaging of an object to be imaged comprising the steps:

(a) generating an incident optical wave, of frequency  $f_I$ , and a reference optical wave, of frequency  $f_R$ , this reference wave being coherent with the incident wave, and exhibiting therewith a known phase difference  $\phi_I(t)$ ,

(b) vibrating in a first object direction and at an acoustic frequency  $f_A$ , a zone of the object to be imaged with the aid of a vibration generating device,

(c) applying said incident wave to the object to be imaged, and thus generating a scattered signal wave,

(d) applying at least a part of the scattered signal wave to a detection device,

(e) applying the reference wave to the detection device without making it pass through the object to be imaged, thereby generating at the point  $r$  of the detection device an interferogram  $I(r, t)$  varying over time  $t$ ,

(f) extracting a digital information item from the interferogram  $I(r, t)$ , and estimating the complex amplitude  $E_s(r)$  of the acoustic component on the basis of the interferogram  $I(r, t)$ , and

(g) obtaining the coordinates of a point of measurement of the object to be imaged, to which the digital information item relates

~~in which in the course of step (f), the complex amplitude  $E_s(r)$  of the acoustic component is estimated on the basis of the interferogram  $I(r, t)$ .~~

10. (Original) The method of acousto-optical imaging as claimed in claim 9, in which the detection device used is a monopixel detector, and in which, in the course of step (f), the digital information item is obtained as being the intensity of the field of complex amplitude  $E_s(r)$  scattered by the object.

11. (Original) The method of acousto-optical imaging as claimed in claim 9, in which the detection device used is a multipixel detector, and in which in the course of step (f), the digital information is extracted as being the sum over at least a part of the pixels  $r$  of the detection device of the intensity of the complex amplitude field  $E_s(r)$  scattered by the object.

12. (Original) The method of acousto-optical imaging as claimed in claim 9, in which, in the course of step (d) a spatial filtering device is used, in such a way as to limit, along at least one direction, the angular extent of the part of the scattered signal wave which is seen by each pixel of the detection device.

13. (Original) The method of acousto-optical imaging as claimed in claim 12, in which a spatial filtering device comprising a diaphragm, of dimensions X along a first diaphragm direction and Y along a third diaphragm direction, and a lens of focal length L with object focus situated directly downstream of the object to be imaged is used so as to limit the angular extent of the part of the scattered signal wave which is seen by each pixel of the detection device, and in which the reference wave applied to the detection device is globally a plane wave.

14. (Original) The method of acousto-optical imaging as claimed in claim 12, in which is used a spatial filtering device comprising a diaphragm of dimensions X along the first diaphragm direction and Y along the third diaphragm direction, disposed between the object to be imaged and the detection device at a distance L from the latter, so as to limit the angular extent of the part of the scattered signal wave which is seen by each pixel of the detection device, and in which the reference wave applied to the detection device is a spherical wave emanating from a source point situated in the plane of the diaphragm.

15. (Original) The method of acousto-optical imaging as claimed in claim 12, in which the reference wave and the scattered signal wave interfere on the detection device while forming a nonzero angle  $\theta_Y$ ,  $\theta_Y$  being measured in the plane of incidence of these two waves on the detection device.

16. (Original) The method of acousto-optical imaging as claimed in claim 12, in which the detection device used is a multipixel detector, and in which the part of the acoustic component, of complex amplitude  $E_s(r)$ , which varies rapidly in space in the plane of the detection device is isolated.

17. (Original) The method of acousto-optical imaging as claimed in claim 12, in which the detection device comprises pixels disposed as a matrix comprising rows along a first detector direction and columns along a third detector direction, and in which step (f) comprises the following steps:

- (f1) for at least one row or column a 1D-Fourier transform is done along this row or column of the detection device to the space of wave vectors, of the complex amplitude of the field  $E_s(r)$ , and a field  $TF_1 E_s(k)$ , is thus obtained for this row or column,
- (f2) several zones of summation are defined in the space of wave vectors,
- (f3) the intensities of the field  $TF_1 E_s(k)$  at each point  $k$  of at least one zone are summed in this zone, and
- (f4) the digital information item is extracted as being a linear combination of the sums thus obtained at each zone.

18. (Original) The method of acousto-optical imaging as claimed in claim 12, in which the detection device comprises pixels disposed in a matrix comprising rows along a first detector direction and columns along a third detector direction, and in which step (f) comprises the following steps:

- (f1) a 2D-Fourier transform is done of the complex amplitude  $E_s(r)$ , from the plane of the detection device to the space of wave vectors, and a field  $TF_2 E_s(k)$ , is thus obtained,
- (f2) several zones of summation are defined in the space of wave vectors,
- (f3) the intensities of the field  $TF_2 E_s(k)$  at each point  $k$  of at least one zone are summed in this zone, and
- (f4) the digital information item is extracted as being a linear combination of the sums thus obtained at each zone.

19. (Original) The method of acousto-optical imaging as claimed in claim 15, in which the angle  $\theta_Y$  is about equal to  $3Y/2L$ , in which, in the course of step (f2) are defined a first zone of summation, the so-called central zone, a second zone of summation, the so-called left zone, and a third zone of summation the so-called right zone, and in which, in the course of step (f4), the digital information item is extracted as being a linear combination of the value of the sum of the left zone and of the sum of the right zone.

20. (Currently amended) ~~The method of acousto-optical imaging as claimed in claim 1, in which A method of acousto-optical imaging of an object to be imaged comprising the steps:~~

- (a) ~~generating an incident optical wave, of frequency  $f_i$ , and a reference optical wave, of frequency  $f_R$ , this reference wave being coherent with the incident wave, and exhibiting therewith a known phase difference  $\phi_i(t)$ .~~
- (b) ~~vibrating in a first object direction and at an acoustic frequency  $f_A$ , a zone of the object to be imaged with the aid of a vibration generating device,~~
- (c) ~~applying said incident wave to the object to be imaged, and thus generating a scattered signal wave,~~
- (d) ~~applying at least a part of the scattered signal wave to a detection device,~~
- (e) ~~applying the reference wave to the detection device without making it pass through the object to be imaged, thereby generating at the point  $r$  of the detection device an interferogram  $I(r, t)$  varying over time  $t$ ,~~
- (f) ~~extracting a digital information item from the interferogram  $I(r, t)$ , and~~
- (g) ~~obtaining the coordinates of a point of measurement of the object to be imaged, to which the digital information item relates,~~

wherein in the course of step (a),

- a laser source of wavelength  $\lambda$  emits an emission wave, of frequency  $f_L$ ,
- amplitude modulation means of the emission wave, generate a carrier wave of incident frequency  $f_i$ , and at least one amplitude modulation lateral band, which corresponds to a wave of frequency  $f_R$ ,

- a semireflecting mirror, transmits a part of the lateral band wave and a part of the carrier wave forming the incident wave, and reflects a part of the carrier wave and a part of the lateral band wave forming the reference wave.

21. (Currently amended) ~~The method of acousto-optical imaging as claimed in claim 1, in which A method of acousto-optical imaging of an object to be imaged comprising the steps:~~

- (a) ~~generating an incident optical wave, of frequency  $f_i$ , and a reference optical wave, of frequency  $f_R$ , this reference wave being coherent with the incident wave, and exhibiting therewith a known phase difference  $\phi_i(t)$ ,~~
- (b) ~~vibrating in a first object direction and at an acoustic frequency  $f_A$ , a zone of the object to be imaged with the aid of a vibration generating device,~~
- (c) ~~applying said incident wave to the object to be imaged, and thus generating a scattered signal wave,~~
- (d) ~~applying at least a part of the scattered signal wave to a detection device,~~
- (e) ~~applying the reference wave to the detection device without making it pass through the object to be imaged, thereby generating at the point  $r$  of the detection device an interferogram  $I(r, t)$  varying over time  $t$ ,~~
- (f) ~~extracting a digital information item from the interferogram  $I(r, t)$ , and~~
- (g) ~~obtaining the coordinates of a point of measurement of the object to be imaged, to which the digital information item relates,~~

wherein in the course of step (a),

- a laser source of wavelength  $\lambda$  emits an emission wave, of frequency  $f_L$ ,
- a first acousto-optical modulator transmits a part of the emission wave to form the incident wave on the object to be imaged, and moreover generates a first frequency shifted wave, the frequency of which is shifted by a value  $\delta f_1$ , possibly negative, with respect to the emission wave, and
  - a second acousto-optical modulator intercepts the first frequency shifted wave and generates a second frequency shifted wave, the frequency of which is shifted by a value  $\delta f_2$ , possibly negative, with respect to the shifted wave, the second frequency shifted wave forming the reference wave, the frequency of which is thus shifted in frequency with respect to

the incident wave by a value  $\delta f = \delta f_1 + \delta f_2$ , thus determining a known phase difference  $\phi_i(t)$  between these two waves.

22. (Currently amended) The method of acousto-optical imaging as claimed in claim 1, in which A method of acousto-optical imaging of an object to be imaged comprising the steps:

- (a) generating an incident optical wave, of frequency  $f_i$ , and a reference optical wave, of frequency  $f_R$ , this reference wave being coherent with the incident wave, and exhibiting therewith a known phase difference  $\phi_i(t)$ ,
- (b) vibrating in a first object direction and at an acoustic frequency  $f_A$ , a zone of the object to be imaged with the aid of a vibration generating device,
- (c) applying said incident wave to the object to be imaged, and thus generating a scattered signal wave,
- (d) applying at least a part of the scattered signal wave to a detection device,
- (e) applying the reference wave to the detection device without making it pass through the object to be imaged, thereby generating at the point  $r$  of the detection device an interferogram  $I(r, t)$  varying over time  $t$ ,
- (f) extracting a digital information item from the interferogram  $I(r, t)$ , and
- (g) obtaining the coordinates of a point of measurement of the object to be imaged, to which the digital information item relates,

wherein in the course of step (a), two independent laser sources, locked in phase by electronic slaving, generate the incident and reference waves, exhibiting a known phase difference  $\phi_i(t)$  between them

23. (Currently amended) The method of acousto-optical imaging as claimed in claim 1, in which A method of acousto-optical imaging of an object to be imaged comprising the steps:

- (a) generating an incident optical wave, of frequency  $f_i$ , and a reference optical wave, of frequency  $f_R$ , this reference wave being coherent with the incident wave, and exhibiting therewith a known phase difference  $\phi_i(t)$ ,
- (b) vibrating in a first object direction and at an acoustic frequency  $f_A$ , a zone of the object to be imaged with the aid of a vibration generating device,

(c) applying said incident wave to the object to be imaged, and thus generating a scattered signal wave,

(d) applying at least a part of the scattered signal wave to a detection device,

(e) applying the reference wave to the detection device without making it pass through the object to be imaged, thereby generating at the point r of the detection device an interferogram  $I(r, t)$  varying over time  $t$ ,

(f) extracting a digital information item from the interferogram  $I(r, t)$ , and

(g) obtaining the coordinates of a point of measurement of the object to be imaged, to which the digital information item relates,

wherein in the course of step (a),

- a laser source of wavelength  $\lambda$  emits an emission wave, of frequency  $f_L$ ,
- a semireflecting mirror transmits a part of the emission wave to form the incident wave on the object to be imaged, and transmits a second part of the emission wave,
- a first acousto-optical modulator intercepts the second part of the emission wave and generates a first frequency shifted wave, with frequency shifted by a value  $\delta f_1$ , possibly negative, with respect to the emission wave, and
- a second acousto-optical modulator intercepts the first frequency shifted wave and generates a second frequency shifted wave, the frequency of which is shifted by a value  $\delta f_2$ , possibly negative, with respect to the shifted wave, the second frequency shifted wave forming the reference wave, the frequency of which is thus shifted in frequency with respect to the incident wave by a value  $\delta f = \delta f_1 + \delta f_2$ , thus determining a known phase difference  $\phi_i(t)$  between these two waves.

24. (Original) The method of acousto-optical imaging as claimed in claim 1 in which the object to be imaged is a biological tissue.

25. (Currently amended) The method of acousto-optical imaging as claimed in claim 1 in which A method of acousto-optical imaging of an object to be imaged comprising the steps:

(a) generating an incident optical wave, of frequency  $f_I$ , and a reference optical wave, of frequency  $f_R$ , this reference wave being coherent with the incident wave, and exhibiting therewith a known phase difference  $\phi_i(t)$ ,

(b) vibrating in a first object direction and at an acoustic frequency  $f_A$ , a zone of the object to be imaged with the aid of a vibration generating device,

(c) applying said incident wave to the object to be imaged, and thus generating a scattered signal wave,

(d) applying at least a part of the scattered signal wave to a detection device,

(e) applying the reference wave to the detection device without making it pass through the object to be imaged, thereby generating at the point  $r$  of the detection device an interferogram  $I(r, t)$  varying over time  $t$ ,

(f) extracting a digital information item from the interferogram  $I(r, t)$ , and

(g) obtaining the coordinates of a point of measurement of the object to be imaged, to which the digital information item relates,

wherein the vibration generating device is used to obtain an acoustic cue of the zone of the object to be imaged, and in which the digital information item extracted in step (f) is used jointly with said acoustic cue.

26. (Currently amended) An installation for acousto-optical imaging of an object to be imaged comprising:

- means for generating an incident optical wave, of frequency  $f_I$ , and a reference optical wave of frequency  $f_R$ , this reference wave being coherent with the incident wave and exhibiting therewith a known phase difference  $\phi_i(t)$ ,

- a vibration generating device for vibrating in a first object direction and at an acoustic frequency  $f_A$  a zone of the object to be imaged,

- means for applying the said incident wave to the object to be imaged, thus generating a scattered signal wave,

- a detection device,

- means for applying at least part of this scattered signal wave to the detection device,

- means for applying the reference wave to the detection device without making it pass through the object to be imaged, thereby generating at point r of the detection device an interferogram  $I(r, t)$  varying over time  $t$ , and

- means for extracting a digital information item, estimating the complex amplitude  $E_s(r)$  of the acoustic component on the basis of the interferogram  $I(r,t)$ , and obtaining the coordinates of a point of measurement of the object to be imaged, to which the digital information item relates, from the interferogram.

27. (Original) The installation for acousto-optical imaging as claimed in claim 26 furthermore comprising the following elements:

- means for visualizing said digital information item relating to said point of measurement of the object to be imaged, and  
- means for displacing the object to be imaged.

28. (Original) The installation for acousto-optical imaging as claimed in claim 26, furthermore comprising a spatial filtering device situated downstream of the object to be imaged.

29. (New) The method of acousto-optical imaging as claimed in claim 6, in which at least steps (a) to (g) are repeated after having imposed a displacement of the vibration generating device relative to the object to be imaged along a direction not parallel to the first object direction ( $x_0$ ) of the object to be imaged.

30. (New) The method of acousto-optical imaging as claimed in claim 6 in which the object to be imaged is a biological tissue.

31. (New) The method of acousto-optical imaging as claimed in claim 9 in which the object to be imaged is a biological tissue.